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Planning Practices of Station-City Integration for Zhengzhou East Railway Station and Surround

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Abstract: Leveraging a high-speed rail hub to promote the development of surrounding areas and the integrated growth of transportation, industry, and space can enhance the synergy between railway construction and urban development. This paper systematically reviews the planning practices of Zhengzhou East Railway Station and its surrounding areas, highlighting successful experience in the station-city integration of high-speed rail hubs. Key achievements include the strategic alignment of high-speed rail hub location with urban spatial development goals, the establishment of an integrated transportation system for station–city integration, the hub-industry-space interaction, and the interconnected three-dimensional spaces. Based on the summary and reflection on these planning practices, this paper suggests that high-speed railway hubs should transform into open and integrated urban complexes, aiming to provide first-class services and ensuring scientific reservation of support facilities for high-speed rail hubs. Since its opening, Zhengzhou East Railway Station has significantly driven the development of its surrounding areas, embodying the concept of symbiosis between railway hubs and cities and realizing the early-stage vision of a hub-driven, station-city integrated development. The core area around the hub has become the most vibrant business center in the Central Plains region. In the future, Zhengzhou East Railway Station will grow in an intelligent, shared, and multi-functional direction, better meeting the development demand for station-city integration. **DOI:** 10.13813/j.cn11-5141/u.2024.0503-en

Keywords: transportation planning; high-speed rail hub; station-city integration; hub-industry-space; Zhengzhou East Railway Station

0 Introduction

With the rapid development of high-speed railways, it has become a consensus to promote the development of surrounding areas relying on high-speed rail hubs and to facilitate the integrated development of transportation, industry, and space. Generally speaking, the development and construction of China's high-speed railway hubs and surrounding areas are in the primary stage, and are not attractive enough to the population and industries. In 2018, the Guiding Opinions on Promoting the Rational Development and Construction of the Areas around High-Speed Railway Stations (No. 514 [2018] of the National Development and Reform Commission) was released, which stipulates strengthening the guiding and regulatory roles of planning, rationally determining the functional orientation around the stations, highlighting the industry-city integration and station-city integration, and synchronously planning and coordinating in urban functional layout, comprehensive transportation system, and infrastructure sharing, fostering the benign interaction between high-speed rail construction and urban development.

Station-city integration implies that through the coordination of planning, construction, and operation, railway passenger stations and surrounding areas can achieve the efficient integration of transportation and urban functions, the coordinated and unified management and operation, and the organic connection of spatial texture, thereby better realizing the linkage effect between railway construction and urban development [1]. Since its operation in 2012, Zhengzhou East Railway Station has vigorously explored the integrated development with surrounding areas by capitalizing on the advantages of the high-speed rail hub for more than a decade and has achieved remarkable results, emerging as the most dynamic business district in the Central Plains region. This paper comprehensively summarizes the practical experience of station-city integration planning for Zhengzhou East Railway Station and its surrounding areas from the aspects of high-speed rail hub site selection, construction of a comprehensive transportation system for station-city integration, hub-industry-space integration, and development achievements of the high-speed rail hub and its surrounding areas.

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1 High-speed rail hub location conforming to urban spatial development strategy

1.1 Hub location and advantages

According to the National Medium- and Long-Term Railway Network Plan in 2004, the Beijing-Guangzhou passenger dedicated line and the Xuzhou-Lanzhou passenger dedicated line intersected in Zhengzhou City, jointly forming a "double-cross" railway structure with the existing "cross" between Beijing-Guangzhou Railway and Longhai Railway. This structure could not meet the passenger transport demand relying solely on Zhengzhou Station. In 2004, after a joint study by the Ministry of Railways and Henan Province, it was decided to build Zhengzhou East Railway Station. The location of the high-speed rail hub has a far-reaching influence on urban development. At that time, the planning and construction of Zhengdong New District had already started. Selecting the high-speed rail hub in Zhengdong New District conformed to the overall requirements of Zhengzhou City to expand the urban framework, build a multi-center city, and relieve the agglomeration pressure in the old urban area, which was consistent with the urban development direction. At the same time, the newly planned Zhengzhou East Railway Station stood side by side with the existing Zhengzhou Station in the east-west direction, forming a railway passenger hub layout with a clear division of labor and coordinated capacity.

Zhengzhou East Railway Station was finally located close to East Third Ring Road (the auxiliary road of National Highway 107) in Zhengdong New District (Fig. 1). From the perspective of urban spatial development and transportation resources, this location has great advantages: (1) It is about 5 km away from the central urban area, which is beneficial to attracting passenger flow and connecting urban transportation; (2) It is close to the mature urban development area. In the initial stage, it can share supporting facilities with the old urban area to realize intensive use of resources; (3) It is relatively close to the CBD of Zhengdong New District and can drive the development of industries such as exhibition and office, which is conducive to the formation of a new urban center; (4) East Third Ring Road (the auxiliary road of National Highway 107) is an urban expressway loop, which is conducive to the rapid distribution of passenger flow; (5) The green spaces between various groups in Zhengzhou City can be used to reduce the impact of high-speed rail lines on urban planning areas; (6) The urban section of the passenger dedicated line adopts an elevated form, and makes good crossings with the intersecting roads, which reduces the division of urban space.

1.2 Hub scale

According to the forecast, the annual passenger dispatch volume of Zhengzhou East Railway Station in 2030 will be 71.8 million person-times, with a daily average dispatch volume of 196 700 passengers·d^{-1}. The railway station line scale consists of 16 platforms and 32 tracks. There are 16 tracks in the Beijing-Guangzhou Line in the west, 4 tracks in the intercity field in the middle, and 12 tracks in the Xuzhou-Lanzhou Line in the east. Additionally, the arrival and departure lines of Zhengzhou-Chongqing High-Speed Railway, Zhengzhou-Jinan High-Speed Railway, and the intercity railways in the Central Plains urban agglomeration are reserved. The total construction area of Zhengzhou East Railway Station is approximately 410 000 m^2, among which the station building area is about 150 000 m^2, the platform awning area is about 78 000 m^2, and the building areas of the subway, under-bridge passages, and parking lots are about 164 000 m^2. The floor area of the waiting hall of Zhengzhou East Railway Station is 12 000 m^2, and the designed peak-hour passenger dispatch volume is 7 400 people, with the maximum gathering number being 5 000.

2 Construction of the station-city integrated comprehensive transportation system

After the site of Zhengzhou East Railway Station was determined, it learned from the successful experience of other high-speed rail hub areas, integrated various transportation resources, and efficiently organized the hub transportation and urban transportation to actively build an efficient and convenient station-city integrated comprehensive transportation system, reducing the adverse impact of the railway passenger station on the division of urban space.

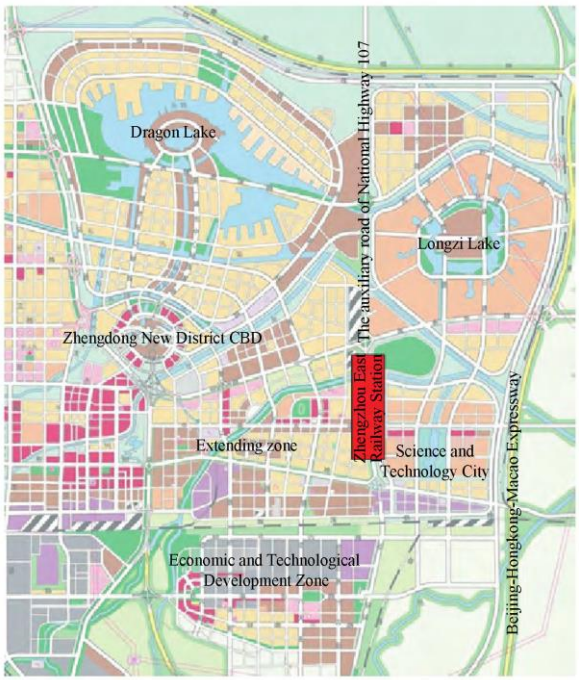

Fig. 1 Location of Zhengzhou East Railway Station

Source: Conceptual Master Plan for Zhengdong New District.

2.1 Internal traffic organization of the hub

Zhengzhou East Railway Station is a large multifunctional comprehensive transportation transfer hub with high-speed railroad as its core, including intercity railway, highway passenger transport, urban rail transit, public buses, taxis and social vehicles. As shown in Fig. 2, the station building is laid out on 6 floors. The third floor above ground is the passenger waiting floor, including functions such as the waiting hall, the station entrance hall, and the elevated drop-off platforms for cars and taxis. The second floor above ground is the high-speed rail platform floor, which includes functions such as high-speed rail tracks, the platform floor, VIP rooms, and VIP vehicle pick-up (drop-off) areas. The ground floor is the passenger exit floor, which includes functions such as the exit passage, the ticket office, the station front distribution square, the car parking lot, the taxi pick-up area, the public transportation station, and the long-distance bus station and other functions. The first floor underground is the subway station hall floor. The second floor underground is the platform floor of Metro Line 1, and the third floor underground is the platform floors of Metro Line 5 (regular line) and Metro Line 8 (express line B).

The overall traffic flow organization in the station building is “up-in and down-out” (Fig. 3). The inbound passenger flows from elevated ramps, public trams, long-distance buses, and subways all enter the station through the waiting hall on the third floor. The outbound passenger flows transfer to cars, taxis, public trams, subways, and other transportation modes on the ground floor to leave the station.

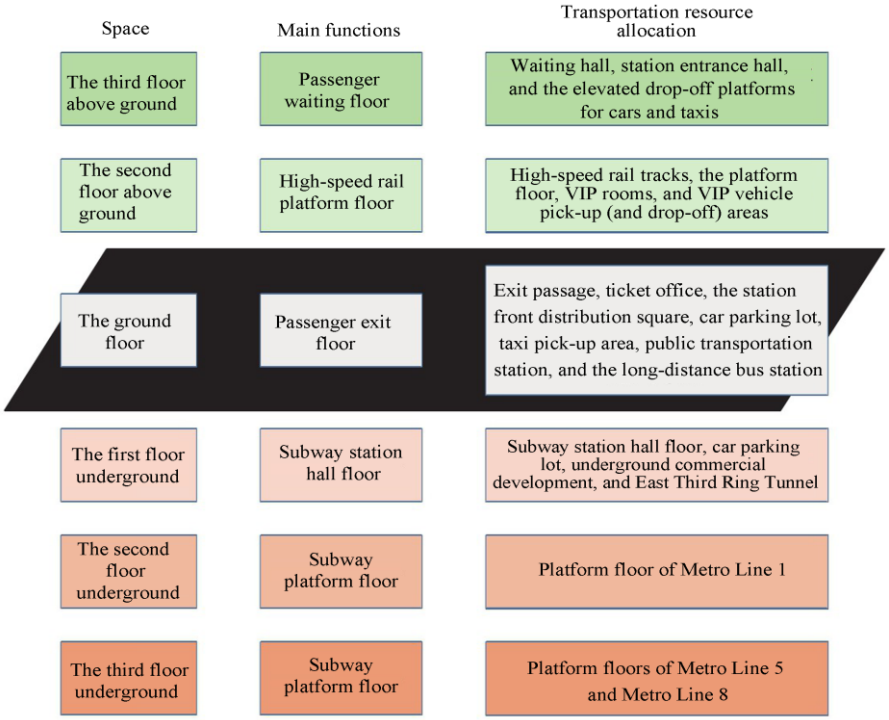

Fig. 2 Illustration of hierarchical traffic organization of Zhengzhou East Railway Station

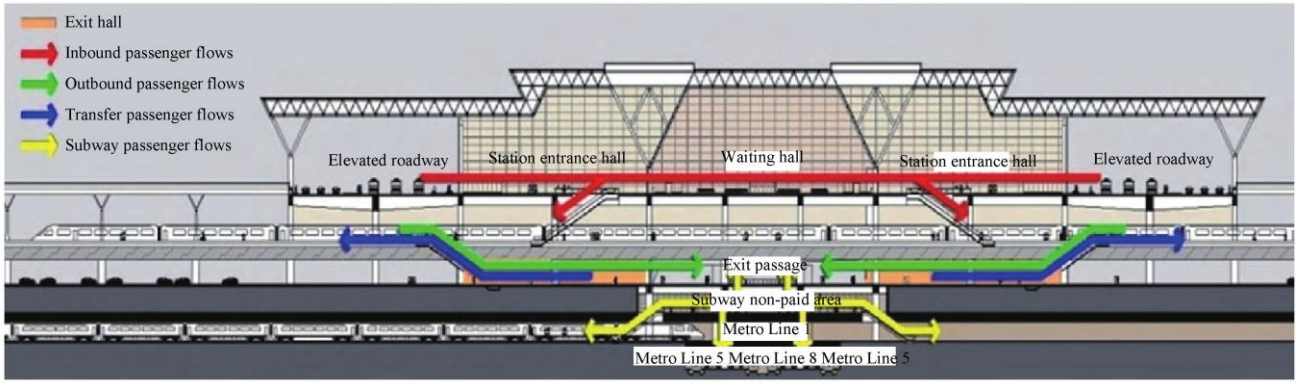

Fig. 3 Organization of vertical traffic flow inside the building of Zhengzhou East Railway Station

Source: Ref. [2].

2.2 Internal and external transportation integration

1) Intensive and efficient layout of distribution facilities

To reduce the transfer distance of passengers, an overhead concept for the station area was proposed to arrange the distribution facilities (Fig. 4). The overhead ground floor was used to set up east-west square passages, railway exit halls, transfer passenger waiting halls, subway entrances and exits, and related service facilities, thus helping passengers transfer nearby. On the ground floor north of the station building, taxi areas, social vehicle parking lots, and long-distance bus, and high-speed rail transfer areas were arranged. On the ground floor south of the station building, taxi areas, social vehicle parking lots, and public bus parking (departure) areas were set up. Metro lines 1, 5, and 8 form a cross-transfer hub station in the west square [2]. Currently, the connection of the citywide rapid rail transit line K2 (express line A) to Zhengzhou East railway station is being planned.

2) Rapid distribution of hub traffic

Zhengzhou East Railway Station is a "station-bridge integrated" overline railway station building. The entrance and exit adopt the up-in and down-out method. "U"-shaped one-way elevated ramps were planned on both north and south sides of the station building, directly reaching the third floor of the station building. The flow line on the north side is west in and east out, and the flow line on the south side is east in and west out. The total length of the ramps is 7 721 m.

To separate from the ground traffic in the area and realize the rapid distribution of hub traffic, a "remote-leading" ramp layout was adopted to directly introduce the entrance and exit traffic flows from the urban trunk roads into the expressway network system, forming a smooth connection between the high-speed rail hub and the urban high (express) speedway system and reducing the impact on the surrounding urban traffic.

3) Multi-level rail transportation system serving the high-speed rail hub and surrounding areas

The high-speed rail hub takes the "米"-shaped high-speed rail lines as the core and simultaneously opens provincial intercity railways, including Zhengzhou-Kaifeng Intercity, Zhengzhou-Jiaozuo Intercity, and Airport Intercity. While strengthening the status of the high-speed rail hub, it realizes the connection in series with important comprehensive transportation hubs such as the airport, Zhengzhou South Station (now Zhengzhou Airport Station), and Zhengzhou Station, jointly forming an air-rail consortium radiating the Central Plains urban agglomeration.

The high-speed rail hub has been connected to three lines, namely, metro lines 1, 5, and 8. Along with the newly planned urban rapid rail transit line K2, it not only realizes close connections with other comprehensive transportation hubs in Zhengzhou City and various functional clusters but also forms a line-station layout of 4 lines and 6 stations in the high-speed rail hub and its surrounding areas, meeting the high-demand and high-coverage requirements for rail transportation travel in the high-speed rail hub and its surrounding areas.

2.3 Separation of hub traffic from urban traffic

1) Separation of hub Traffic and through traffic

Zhengzhou East Railway Station is close to East Third Ring Road. An underpass tunnel is planned in the front square of the station to purify the ground square. Meanwhile, ground entrances and exits are set at both ends of the tunnel to form a conversion with the incoming and outgoing traffic of the high-speed rail hub, achieving the separation of hub traffic and through traffic.

2) Moderate separation of station-city traffic in the high-speed rail hub and its surrounding areas

The plan for the connection of railway lines crossing urban roads is prepared in advance, making the average spacing of the crossing railway passages reach 0.7 km, reducing the division of urban space by the railway, forming a micro-circulation in the area, and realizing the moderate separation of station-city traffic.

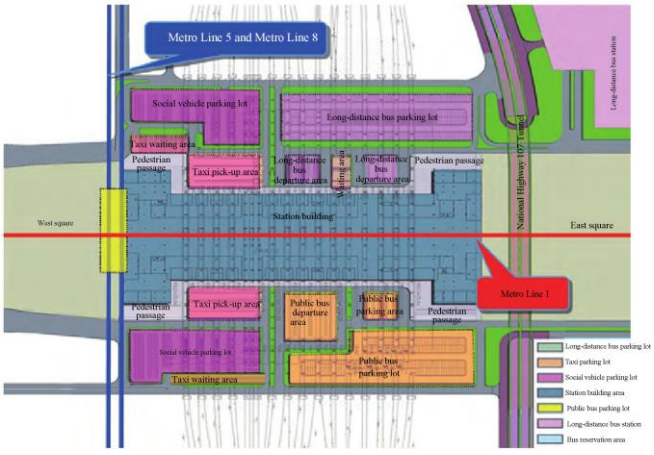

Fig. 4 Overall layout of distributing facilities at Zhengzhou East Railway Station

Source: Ref. [3].

3 Hub-industry-space interactive integration

3.1 Internal driving force of station-city integration development

With the accelerated progress of regional economic integration, a large number of production and service enterprises as well as scientific innovation, R&D, and office institutions that require high-level cooperation across cities and regions have emerged in urban clusters and metropolitan areas. This has generated the demand for rapid intercity travel, which is mainly characterized by high frequency, short and medium distances, high sensitivity to time value, low sensitivity to cost, and high requirements for comfort and convenience. The advantages of high-speed rail can maximally meet this type of travel demand with its rapidity, punctuality, and comfort. Therefore, such passenger groups and the institutions and industries that generate a large number of such travel needs are the internal requirements for the development of the areas surrounding high-speed rail hubs and the internal driving force for station-city integration.

Through a large number of studies on land development cases around high-speed rail hubs, a hierarchical structure model of land use layout is proposed (Fig. 5). This model divides the influence area of the high-speed rail hub into three zones: the core zone, the expansion zone, and the peripheral influence zone [4]. Among them, the core zone has a radius of 800 m and is developed with high density. It takes 5–10 min to walk to the high-speed rail hub, and functions such as transportation, business, commerce, and office are arranged; the expansion zone has a radius of 1 500 m, and it takes 10–15 min to walk to the high-speed rail hub. It is suitable for the layout of mixed residential and public service land, and the development intensity of this zone decreases with the increase of the distance from the high-speed rail hub; the peripheral influence zone is outside the radius of 1 500 m, and mainly has functional zones that play a supporting role for the functions of the core zone [5].

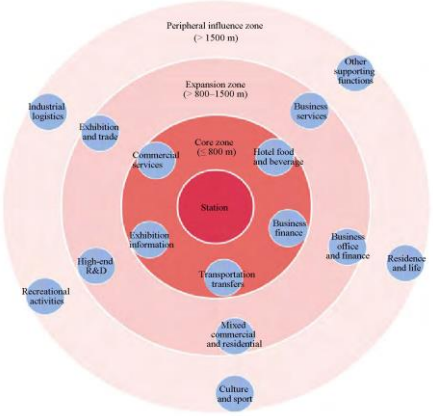

Fig. 5 Hierarchical structure model of land use layout in the surrounding areas of the high-speed railway hub

3.2 Optimization of spatial structure and industrial layout in the region surrounding the high-speed rail hub

After the site selection of Zhengzhou East Railway Station, the spatial structure of the region surrounding the high-speed rail hub was actively adjusted. The area enclosed by Zhongzhou Avenue–Xiong'er River–Dongfeng Canal–East Fourth Ring Road–Longhai Road was designated as the comprehensive transportation hub area, with a total area of 35.05 km^2. The comprehensive transportation hub area aims at the integrated development of "hub–industry–space" and determines the regional function orientation as an important national comprehensive transportation hub, an important national logistics center, and the sub-center of Zhengzhou City. At the same time, a provincial administrative service center was arranged within 2–3 kilometers around Zhengzhou East Railway Station. The radiation effect of the provincial capital city on the Central Plains urban agglomeration has generated a large number of rapid intercity passenger travel demands.

The comprehensive transportation hub area utilizes the hierarchical concept to optimize the industrial layout of the hub and its surrounding areas. Taking the comprehensive transportation hub as the core, it is equipped with and perfected functions such as office, exhibition, commerce, logistics, and residence (Fig. 6), forming a spatial structure of "one center, four axes, and eight regions". "One center" refers to the transportation function core formed by Zhengzhou East Railway Station and the long-distance passenger terminal. "Four axes" refer to one central landscape axis, two business office axes, and one commercial logistics axis. "Eight regions" refer to one hub core region, which develops functions such as business, headquarters, and R&D closely related to the high-speed rail hub; one business office region, which strengthens the connection with the CBD; one commercial logistics region and one national trunk logistics port; and four residential supporting function regions of the industrial regions are arranged around [4], maximizing the function of Zhengzhou East Railway Station in leading the development of the Zhengdong New District.

The scope of the hub core region is defined as the area enclosed by Dongfeng South Road–Mingli Road–Qilihe South Road–Shangding Road, with an area of 2.7 km^2. The hub core region has the strongest functional and spatial correlation with the station, and function lands such as enterprise headquarters, high-end business, five-star hotels, R&D, and exhibitions are mainly arranged. The above-ground building area is 7.548 million m^2, and the underground building area is 3.209 million m^2. Commercial and business lands are successively arranged along the central landscape axis from the east and west squares outward, and the development intensity and building height increase from the center to the north and south sides, forming a concave urban form with a low middle and high sides. The plot ratio of the hub core region is shown in Fig. 7.

a Land use planning

b Functional zoning and industrial layout

Fig. 6 Optimization of the spatial structure of the integrated transportation hub

Source: Ref. [6]

Fig. 7 Floor area ratio of the core hub area

Source: Ref. [7]

3.3 Three-dimensional space interconnection in the hub core area

To achieve the station-city integration of the high-speed rail hub and the surrounding areas, three-dimensional space extensions are made from the axes of the east and west squares to the adjacent blocks in the north and south directions, ensuring the continuity and efficiency of the functions from the high-speed rail hub to the urban functions.

1) The three-dimensional development of the space of the station square realizes the seamless connection between the station and the city

Large underground transportation and commercial spaces are set up beneath the east and west squares with functions including underground parking lots, underground commercial streets, underground street crossings, urban rail transit stations, and civil air defense engineering. The two parts of the underground space of the east and west squares

are connected by the inherent connection channels beneath the station building. The underground pedestrian space of the west square is seamlessly connected with the urban rail transit space, and two connection channels are reserved with the north-south underground pedestrian street on Xinyi Road on the west side of the square. The underground transportation and commercial space of the east square extends northward across Dongli North Road to the long-distance passenger transport hub plot and eastward across Putianxi Road to connect with the three-dimensional pedestrian system in the core area, realizing the seamless connection from the functions of the high-speed rail hub to the functions of the city (Fig. 8).

2) The three-dimensional pedestrian system boosts the development vitality of the hub core area

The east square region is mainly developed into a comprehensive urban gateway area integrating a high-speed rail hub, international finance, high-end business, leisure, and entertainment. In combination with the characteristics of pedestrian flow distribution, a three-dimensional pedestrian system with the underground as the main part, the ground as the secondary part, and the surface as the complement is designed. A four-level pedestrian network of "main–secondary–branch–internal passages" is established, forming 3.6 km of underground pedestrian passages, 1.4 km of aerial pedestrian corridors, and a ground pedestrian passage density of approximately 10 km·km^{-2} [8] (Fig. 9). The three-dimensional pedestrian system connects the underground and above-ground spaces of around 50 plots, including various construction forms such as underground pedestrian crossings, underground pedestrian commercial streets, aerial pedestrian corridors, urban rail transit connection passages, and internal open passages. At key nodes, viewing platforms, performance areas, rest areas, commercial areas, and exhibition areas are constructed to fulfill different functional requirements and enhance the quality and comfort of the pedestrian environment.

3) The underground loop system supports the high-quality development of ground transportation

To address the traffic distribution issue resulting from high-intensity development, an underground loop system linking various public buildings, commercial, and business plots is planned in the core area of the east square. On the one hand, it realizes the sharing of regional parking resources and ameliorates the regional arrival and departure traffic conditions. On the other hand, it cedes more right-of-way resources to public transportation to create an ecological and comfortable pedestrian traffic environment. The total length of the main loop corridor of the underground loop is 2.9 km, with 12 loop entrances and exits, and approximately 6 000 underground public parking spaces are connected in series through 3 groups of block tunnels [9].

4 Achievements of station-city integration

4.1 Continuous growth of passenger flow

On September 28, 2012, Zhengzhou East Railway Station was put into operation. Only the Zhengzhou–Xi'an High-Speed Railway and the Zhengzhou–Guangzhou section of the Beijing–Guangzhou High-Speed Railway were opened at that time. On December 26, 2012, the entire Beijing–Guangzhou High-Speed Railway was opened. On December 28, 2014, the Zhengzhou–Kaifeng Intercity Railway was opened. On December 31, 2015, the intercity railway from Zhengzhou East Railway Station to Xinzheng Airport was opened. On July 1, 2016, the Zhengzhou–Xuzhou High-Speed Railway was put into use. The passenger volume of Zhengzhou East Railway Station has been steadily increasing.

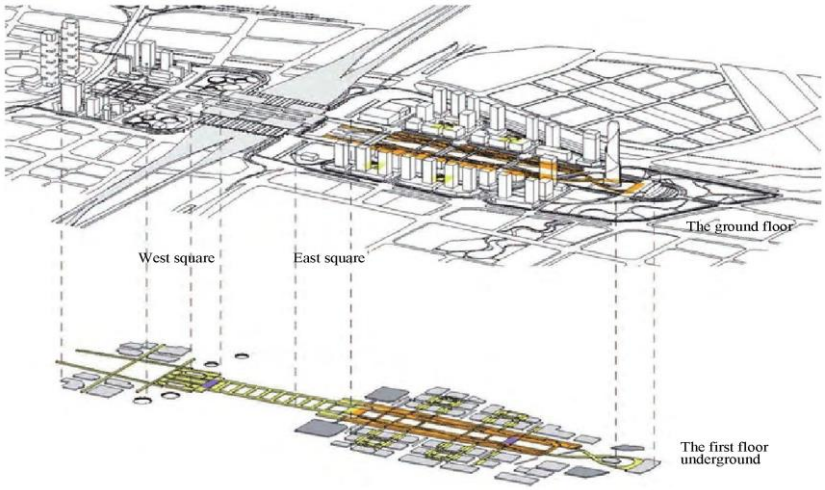

Fig. 8 Layout of Zhengzhou East Railway Station Square and the underground space in the core area

Source: Ref. [7]

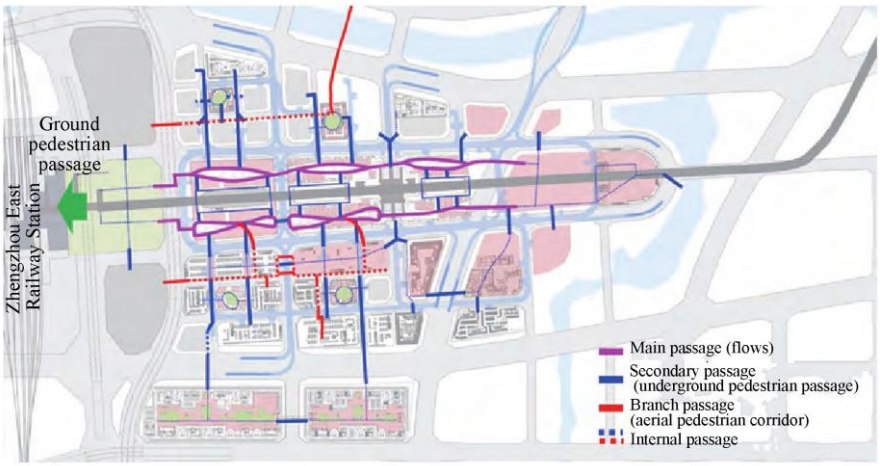

Fig. 9 Three-dimensional pedestrian system in the core hub area

Source: Ref. [8]

1) Passenger volume during holidays

On April 30, 2016, the passenger volume was 47 000 person-times. On April 2, 2017, the passenger volume was 101 000 person-times. On April 29, 2017, the passenger volume was 97 000 person-times. On June 16, 2018, the passenger volume was 106 000 person-times. On October 1, 2020, the passenger volume was 186 000 person-times.

2) Passenger volume during the summer vacation

During the summer vacation in July and August 2017, the passenger volume was 4.12 million person-times, an increase of 1.76 million person-times compared with that of 2016, with a growth rate of 42.7%.

3) Passenger volume during the Spring Festival travel rush

During the Spring Festival travel rush in 2017, the passenger volume was 2.17 million person-times, with an average daily volume of 54 000 person-times. During the Spring Festival travel rush in 2019, the passenger volume was 2.95 million person-times, with an average daily volume of 74 000 person-times. During the Spring Festival travel rush in 2021 and 2022, the passenger volumes were 2.7345 and 2.235 million person-times, respectively. In 2023, with the formation of a "米"-shaped high-speed railway network, the passenger volume during the Spring Festival travel rush was 4.314 million person-times, with a single-day peak of 151 000 person-times. During the Spring Festival travel rush in 2024, the passenger volume was 5.566 million person-times, with a single-day peak of 174 000 person-times.

4.2 Convenient transportation transfer

1) Public transportation

By 2023, there were 19 bus routes passing through Zhengzhou East Railway Station, among which 3 were night routes. Most of these routes took Zhengzhou East Railway Station as their starting or terminal station. The metro lines passing through Zhengzhou East Railway Station included Line 1, Line 5, and Line 8. Among them, Line 1 was put into operation on December 28, 2013, connecting Zhengzhou Station and Zhengzhou East Station; Line 5 was opened for operation on May 20, 2019. Line 8 started construction in May 2020 and was expected to be opened in December 2024.

2) Car traffic

As the demand for car travel increased, Zhengzhou East Railway Station expanded the scale of social vehicle parking lots by integrating regional resources and set up parking guidance systems on the surrounding roads. Besides the P1 and P3 parking lots in the station building, four new public parking lots were added. Among them, the P5 parking lot had a new area for online car-hailing parking; the P6 parking lot was set up using the remaining parking spaces in office buildings and mainly provided parking services for overnight vehicles.

3) Special services of air-rail intermodal transportation

To enhance the service level of the intercity railway from Zhengzhou East Railway Station to Xinzheng Airport, since June 13, 2016, 8 new self-service check-in systems have been added at Zhengzhou East Railway Station, distributed in the waiting hall on the 3rd floor of the station. Passengers holding ID cards or passports can apply for boarding passes and choose cabin seats in the waiting hall of Zhengzhou East Railway Station, and then take the intercity railway to the airport, realizing the service function of the "city terminal".

4.3 Integration with surrounding areas

The Greenland Center Twin Towers and the Sports Park in the west square area centered around Zhengzhou East Railway Station have been basically completed. The occupancy rate of the commercial office buildings typified by the Twin Towers is high, being brimming with popularity and vitality. Depending on the advantages of the high-speed rail hub, the development of the east square has formally commenced and high-quality projects have been successively implemented. Many renowned enterprises such as China Resources New Times Square (commercial complex + office

+ hotel), Starlink Center (office + hotel), Zhengshang International Building (office), and Zhongyuan Headquarters Base have entered (see Fig. 10), injecting a powerful stimulus into the dynamic development of the whole region. The business core of Zhengdong New District has achieved the shift and elevation from the CBD to the high-speed rail hub area.

5 Implications

5.1 Summary of experience

The starting point of station-city integration is to address the problem of the separation between railway passenger stations and cities. Its objective is to fully play the synergistic and linkage effects between railway construction and urban development, exploit the potential of railway passenger station construction in urban renewal, industrial upgrading, and structural transformation, and achieve the new value of railway passenger stations in "transcending transportation" [1]. Reviewing the development process of Zhengzhou East Railway Station and its surrounding areas, we can find that the introduction of the high-speed rail hub has provided an opportunity for the development of the new area, and through the linkage of hub–industry–space, the optimization of industrial layout and spatial structure has been guided and the symbiotic and coordinated development of the high-speed rail hub and the city has been realized.

1) Planning and site selection conforming to urban development strategies

The site selection of Zhengzhou East Railway Station was carried out at the time of rapid development of urbanization. The selection of the site in Zhengdong New District aimed to take the construction of the high-speed rail hub as an opportunity to promote the transformation of the city from a single-center development to a multi-center layout, guide the adjustment of urban spatial structure and industrial structure, and support the expansion of the urban framework, which was in line with the overall development strategy of Zhengzhou.

2) The spatial location of the high-speed rail hub site selection matches the urban growth potential

Fig. 10 Development projects in the surrounding area of Zhengzhou East Railway Station

Source: Ref. [9].

China's new high-speed railway stations are generally far away from the old urban areas and the speed of station-city integration and regional development is significantly lower than expected. The site selection of Zhengzhou East Railway Station took into account the correlation with the old urban area, which is about 5 km away from the old urban area, ensuring that in the initial stage of development, it can share infrastructure facilities in the central urban area, ensuring the passenger flow attraction of the high-speed rail hub.

3) The construction of the high-speed rail hub interacts and integrates with industry and space

There is a mutual feedback relationship between the high-speed rail hub and land use. Relying on the influence of the high-speed rail hub, the surrounding areas vigorously develop industries closely related to the hub economy in accordance with the concept of spatial circle, realizing the coordinated development of transportation, industry, and space. In the surrounding areas of Zhengzhou East Railway Station, business core areas, Zhengzhou Free Trade Zone, Zhongyuan Science and Technology City, Science Valley and other industrial clusters have been successively built.

4) Achieving integrated connection with the surrounding blocks through a three-dimensional space connection

Railways will divide urban space to different extents and the underground space development model centered around Zhengzhou East Railway Station has improved the spatial integration of the station area and urban blocks. Meanwhile, an interconnected underground loop system has been built in the core area of the east square and a three-dimensional pedestrian system integrating the air, underground, and ground has been organized, which organically connects Zhengzhou East Railway Station with the surrounding urban functional entities.

5) Efficient transportation system underpins station-city integration

The hub traffic aims at efficient gathering and distribution, utilizing the "remote-leading" elevated entrance and exit ramps to blend into the regional rapid distribution system, and the hub traffic and the transit traffic are separated; the underpass railway channels are pre-controlled beforehand to form a regional microcirculation, mitigating the adverse influence of hub traffic on regional development.

6) The intensive layout of the high-speed rail hub realizes the convenient transfer

The space beneath the elevated station building is utilized to form a traffic complex integrating multiple modes, and through intensive and vertical arrangement of distribution facilities, the transfer distance of passengers is minimized as much as possible, and seamless transfer within the high-speed rail hub is basically achieved.

7) Systematic planning and multi-party coordination

The construction of Zhengzhou East Railway Station coordinates multiple departments such as national railways, planning, subways, transportation, and construction. The coordination work is extremely difficult. There were repetitions of the scheme at the beginning of the design. Through the cooperation of multiple owners, a unified platform, unified planning, unified design, and unified construction are carried out to ensure the smooth progress of all constructions.

5.2 Reflection and suggestions

Zhengzhou East Railway Station has achieved certain achievements in providing high-speed rail hub services and leading the development of new areas, but with the development of the times, higher expectations are placed on high-speed rail hub construction and hub services. The Outline for Building China's Strength in Transport proposes to take creating "first-class services" as the strategic development path, construct an integrated comprehensive transportation hub system, promote the rapidity and convenience of travel services, and build a comprehensive transportation hub with international influence. Therefore, this paper reflects on the whole process of the planning, construction, and operation of Zhengzhou East Railway Station and puts forward the following suggestions.

1) Reasonably set the scale of the station square to realize the integration of station and city functions

Although various measures such as the three-dimensional pedestrian system and underground space connection have reduced the division of urban space by the high-speed rail hub, in terms of the spatial scale, passengers still need to walk for 10 minutes to cross the huge station square after getting off the train, so there is still a certain sense of spatial fragmentation. In the future high-speed rail hub construction, an integrated design of the station building, the station square, and property development should be carried out based on rapid transfer. Through vertical development, the station building should be transformed from a single traffic distribution space into a place where transportation, architecture, and urban public space interact and integrate with each other, truly realizing the integration of the high-speed rail hub and the city in space and function.

2) Strengthen the express line connection of urban rail transit between transportation hubs

The three urban rail transit lines connected to Zhengzhou East Railway Station are all general lines. With the expansion of the urban framework, it is difficult to meet the demand for timeliness. It is recommended to introduce urban rail transport express lines to achieve rapid connection between various transportation hubs and enhance the timeliness of hub radiation.

3) The urban rail transit lines introduced to the high-speed rail hub should consider local needs

The core area of the hub has planned a high-intensity business development pattern, but only one urban rail transit line and two stations are reserved, and the capacity and station coverage are difficult to meet the passenger flow demand. It is recommended that when introducing urban rail transit lines to the high-speed rail hub, both the hub traffic

distribution and the commuting travel needs of the area should be taken into account.

4) Improve the integrated service standards of supporting facilities and construct a smart hub

In the transfer function area, it is necessary to promote the combined layout of multiple transportation modes and the sharing of facilities and equipment to achieve the mutual recognition of security checks, information sharing, and one-ticket joint journey. At the same time, the air-rail intermodal service between Zhengzhou East Railway Station and the airport needs to be further strengthened. Currently, it has not yet achieved bus operation, with insufficient attraction for passenger flow, and the linkage effect of the transportation hub is not good.

5) The supporting resources should be intensively and comprehensively utilized

With the gradual formation of the high-speed rail network, the decline of highway passenger transport is evident, the function of the public transport and railway transfer area on the north side of the station building has been adjusted to high-speed rail business and customized tourism services, and there is also a large gap between the passenger volume of the long-distance bus station on the northeast side of the station building and the design expectation. It is recommended to activate the transport station space with a low utilization rate, enhance the overall value, feed back the transport facility construction, and form a virtuous cycle. It is also possible to consider converting the surplus space into "public facilities for both peacetime and emergency time use".

Station-city integration is a dynamic process that evolves with the time, varying from time to time and from place to place. With the development of technologies such as artificial intelligence and autonomous driving and the changes in the requirements of station-city integration policies and mechanisms, the development model of station-city integration will also continue to evolve, requiring continuous exploration and innovation.

References

[1] SHENG H. Conceptual analysis and evaluation factors of station-city integration[J]. Urban transport of China, 2022, 20(3): 8–9. (in Chinese)

[2] Zhengzhou Urban Planning Design & Survey Research Institute Co., Ltd. Station building overhead system engineering planning and design adjustment scheme of New Zhengzhou Station (Zhengzhou East Railway Station high-speed rail hub)[R]. Zhengzhou: Zhengzhou Urban Planning Design & Survey Research Institute Co., Ltd., 2010. (in Chinese)

[3] Zhengzhou Urban Planning Design & Survey Research Institute Co., Ltd. Comprehensive transportation hub and related engineering construction detailed planning of Zhengzhou[R]. Zhengzhou: Zhengzhou Urban Planning Design & Survey Research Institute Co., Ltd., 2009. (in Chinese)

[4] POL P M J. The economic impact of the highspeed train on urban regions[C]//43rd Congress of the European Regional Science Association, Jyväskylä, Finland, 27th-30th August 2003: Peripheries, Centres, and Spatial Development in the New Europe.

[5] XIONG W, WANG S. Study on the spatial distribution pattern of surrounding area under the influence of high-speed railway hub[J]. Shanxi architecture, 2018, 44(1): 31–32. (in Chinese)

[6] Zhengzhou Urban Planning Design & Survey Research Institute Co., Ltd., Land planning survey center of Zhengdong New District. Zhengzhou Comprehensive Transportation Hub (New Zhengzhou Station) area control detailed planning [R]. Zhengzhou: Zhengzhou Urban Planning Design & Survey Research Institute Co., Ltd., Land Planning Survey Center of Zhengdong New District, 2009. (in Chinese)

[7] 株式会社矶崎新·青木宏建筑设计事务所. Urban design of the core area of the integrated transportation hub in Zhengdong New District [R]. 日本:株式会社矶崎新·青木宏建筑设计事务所, 2013.

[8] Zhengzhou Urban Planning Design & Survey Research Institute Co., Ltd. Planning of walking system in the core area of New East Plaza, the comprehensive transportation hub of Zhengdong New District [R]. Zhengzhou: Zhengzhou Urban Planning Design & Survey Research Institute Co., Ltd., 2019. (in Chinese)

[9] Beijing Urban Engineering Design & Research Institute Co., Ltd. Design scheme for the underground road system of the Zhengdong New District comprehensive transportation hub in Zhengzhou [R]. Beijing: Beijing Urban Engineering Design & Research Institute Co., Ltd., 2013. (in Chinese)

